## *Note on the Constitution of Saturn's "Crape" Ring.*

By E. M. Antoniadi.

Some three years ago the idea was suggested by the writer that the phenomena presented by *Saturn's* inner "dark" ring might be explained by assuming the albedo of its particles to be equal, or at any rate comparable to that of the bright rings, in which case the shading marking the projection of this ring on the planet would be merely the shadow cast by that swarm of meteors.*

Before examining the results arrived at by an application of the deductive method to this interpretation, it would be useful to start with a sound notion of the distribution of matter in the "crape" ring. Professor Barnard's observations of the occultation of *Iapetus* in 1889,† and of the physical appearance of the planet in 1894,‡ have shown this ring to be "very thin at its inner edge," and growing "much denser where it joins the bright ring." True, a reversal of these appearances has been often noted with smaller instruments, the "dark" ring showing itself, at the ansæ, brighter towards the globe of *Saturn*. But this effect is evidently of a purely subjective character, the juxtaposition of the bright ring dwarfing to invisibility that part of the "crape" ring lying in its immediate vicinity. Besides, the fact that the "dark" ring is more transparent to the planet's limb towards its inner edge than close to the bright ring is a striking confirmation of its greater rarefaction near *Saturn*.

This point once established, the hypothesis above enunciated leads us to the following conclusions :—

1. Inasmuch as the heliocentric latitude of *Saturn* can attain the value of 2° 30′, the outline of the dusky shadow projected on the globe would not usually be a rigorous continuation of the "nebular" ansæ.

(*a*) Should the Sun be higher above the plane of the ring-

* *Journal of the British Astronomical Association*, vol. vii. pp. 241, 242.
† *Monthly Notices*, vol. l. January 1890.
‡ *Ibid.* vol. lv. May 1895.

system than the Earth, the breadth of the shadow across the planet would shrink along the minor axis.

(*b*) Should the Sun be lower above the same plane than the Earth, the breadth of the shadow would be increased by the additional shadow of the inner edge of the bright ring. But the darkness of this latter shadow, viewed, as it would be, through the thickest (outer) part of the light-scattering swarm, would be considerably attenuated.

2. The real intensity of the "crape" ring's shadow being an inverse function of the Sun's altitude above the plane of the rings, the transparency of the "dark" ring ought to diminish with the closing of the system. For the perspective grouping of the particles would, in this case—

(*a*) Mask more effectively the planet's limb;

(*b*) Whose intensity would be further reduced by the strengthening of the particles' shadow, consequent on their closer apparent grouping.

Now observation confirms both these deductions. With reference to the latter, we find Proctor saying:—"As the ring-system closes up, the distinction between the dark ring and the neighbouring bright ring becomes less marked, the dark ring appears greyish or slate-coloured, the traces of division less distinct (or less frequently to be noticed), while the outline of the planet is either not seen at all through the dark ring, or only seen with difficulty and indistinctly." *

That the first conclusion is also in accordance with experience the writer only recently found out during a visit paid to the Bibliothèque Nationale, Paris. While consulting there the literature on the subject, he came across a statement of Dawes' in the *Monthly Notices* for January 1851, p. 52, running thus:—"I have always † observed that the upper (southern) and more distant portion of the obscure ring is more plainly seen than the corresponding portion on the side nearest to the Earth, and also that the projection of it at its minor axis is considerably narrower than accords with its breadth at the major axis."

The first part of this sentence is a confirmation of Dr. Barnard's results, above alluded to, while the latter half might be accounted for, by the theory we are examining, in the following manner:—At the time of the observations of Dawes—let us say, 1851 January 1—*Saturn* had the following elements:—

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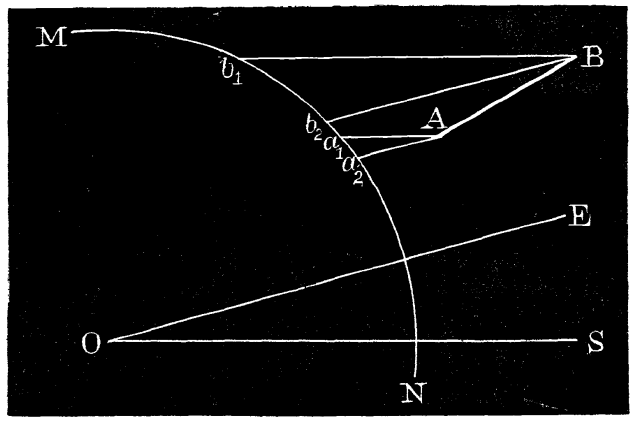
|---|---|
| Heliocentric latitude (almost at its maximum negative value) ... ... ... | − 2° 29′ |
| Heliocentric longitude ... ... ... | 20° 24′ |
| Visible surface of ring system ... ... | Southern |

* *Old and New Astronomy*, p. 632.

† Dawes having seen the "crape" ring for the first time on 1850 November 23, the word *always* cannot embrace more than a few weeks in the past.

Let MN in the annexed figure be the outline of *Saturn*, O its centre, AB the "crape" ring, supposed to consist of particles at




least as bright as the planet's surface, OE the direction of the Earth, OS that of the Sun at the time of Dawes' observation, the angle EOS being, for the sake of clearness, grossly exaggerated. Then the point A of the "crape" ring casts its shadow on the planet at $a_1$ ($Aa_1$ being parallel to SO), B at $b_1$; the arc $a_1b_1$ marking the breadth of the projection of the shadow on the globe. But to the observer on the Earth, the point A is projected at $a_2$ ($Aa_2$ being parallel to EO), B at $b_2$; and it will be seen that the shadow ought to appear shrunk along the minor axis, inasmuch as Dawes was seeing shaded, through the gaps separating the particles along AB, the segment $a_1b_2 < a_2b_2$, the arc $a_1a_2$ suffering no obscuration through the projection on it of particles whose albedo is fully comparable to its own.

Were the "crape" ring to be really a *dark* ring, we ought whenever the heliocentric latitude of *Saturn* is considerable, to be enabled to distinguish the dusky projection from the shadow it would cast on the globe. Such a difference of shade in the band crossing the planet was sought for by the eagle-eyed Dawes in 1852, but in vain. And it is evident that this very failure, which is unaccountable by any idea associated with a dark ring, is a forced corollary of the theory above examined.

In 1884, M. Trouvelot attacked this subject in his valuable paper entitled *Sur la Variabilité des Anneaux de Saturne*, and published in the *Bulletin Astronomique*.* He also thought that the phenomena observed by Dawes and himself could be explained by the "crape" ring's shadow. But the possibility that the albedo of the individual particles of this ring might be identical with that of the bright rings, which is the corner-stone of the writer's interpretation, does not seem to have dawned in M. Trouvelot's mind, for not only does he not make the slightest allusion to this assumption, but furthermore seems unmistakably to espouse

* Numbers for November 1884 and January 1885.

the view that the "crape" ring is really a dark ring, as the following quotation from his paper proves beyond doubt :—"I then attributed," he says, "the phenomenon" (narrowing of the "dark" ring at lesser axis) "to an effect of irradiation of the light of *Saturn's* globe overstepping the material particles composing the border of this ring. Although it might be probable that irradiation must cause a reduction in the diameter of the particles of the ring projected on the globe, I now think, however, that the phenomenon just described results from another cause." As irradiation is capable of affecting the diameter of dark bodies only when put in juxtaposition with a bright one, M. Trouvelot obviously considered the particles of the "crape" ring to be darker than the globe. But then, without irradiation, the segment $a_1a_2$ in the preceding figure ought to be dark, not bright as the planet, as Dawes actually saw it. And thus M. Trouvelot's interpretation is shown to be in opposition to observation.

Irradiation doubtless affects the breadth of the shadow cast on the globe by the "crape" ring, but to a slight extent only, as the intensity of such shadow is also slight. Inasmuch, however, as the luminosity of the planet is greatest about its centre, waning very rapidly towards the limb, the effect due to irradiation would not be uniform, attaining its maximum at the minor axis, its minimum in the vicinity of the limbs, a circumstance which would tend to exaggerate the apparent concavity of the shadow's outline with regard to the centre of *Saturn*.

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## *Observations of the Satellite of Neptune from Photographs taken at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal*).

A number of photographs of Neptune and his satellite (twenty-two in all) have been obtained since December 23 with the Thompson Equatorial, using either the 26-inch refractor or the 30-inch reflector. From January 26 an occulting shutter immediately in front of the plate has been used to screen the planet during the greater part of the long exposure on the satellite, a series of very short exposures (usually twenty of one second each) being given for Neptune at regular intervals (usually each minute) by lifting the occulting arm. In this way small well-defined images of Neptune in combination with distinct images of the satellite have been obtained, the photographs admitting of very accurate measurement of the position angle and distance of the satellite. The orientation was determined usually by means of a pair of short exposure images of Neptune, the clock being put out of gear for seven or ten seconds between the exposures to give a convenient displacement in R.A.